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FINAL REPORT ON SPRUCE BUDWORM EVALUATION SURVEY OF 1959

By
William H. Klein

Division of Forest Insect Research
Pacific Northwest Forest & Range Experiment Station
Portland, Oregon
May 13, 1960

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U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
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SUMMARY

The 1959 spruce budworm evaluation survey was launched August 17 and ended September 11. 24 plots were sampled in known areas of spruce budworm infestation in eastern Oregon. The relationship of the densities of new to old spruce budworm egg masses found on foliage samples was used as an index for estimates of population trend. Information on degree of non-hatching and the relative abundance of associated insects was also obtained.

Spruce budworm egg population levels and trends varied within the region. In northeastern and central Oregon, egg population levels were low and the trend downward; in southern Oregon, egg populations were medium to high and the trend strongly upward. Analysis of egg masses from seven plots in southern Oregon (Fremont National Forest) revealed an unusually high incidence of non-hatching due to parasitism, dessication, and other natural factors. Although this means that the populations will be curtailed somewhat, the epidemic hazard in southern Oregon remains high.

Problems in methodology are briefly discussed. Plans for the evaluation survey in 1960 are given.

INTRODUCTION

The spruce budworm has plagued Douglas-fir and mixed pine-fir stands in Oregon and Washington since 1947. During the last eleven years, aerial spraying has covered some five million acres of infested timber in these two states. Even though the spraying was highly effective on the areas treated, and budworm populations are at the lowest ebb since 1947, this defoliator continues to infest extensive forested areas in Oregon and Washington (table 1).

Through research, methods of assessing the biological status of the spruce budworm have steadily been improved. Egg sampling surveys, begun on a pilot test basis in 1958, were improved and expanded in 1959. These surveys provide information on: (1) Budworm population trend, (2) probable level of budworm populations in the coming year, (3) severity and extent of damage the budworm is expected to cause in the coming year, and (4) status of associated insects. This information is necessary for judging control need and for control planning.

The purpose of this report is to: (1) Present in detail the findings of the 1959 evaluation survey, (2) record procedures for future use, and (3) recommend some improvements in survey techniques. The survey findings have previously been reported in brief. 1/

METHODS

The intensity of survey is limited by time, manpower, and survey efficiency. In 1959, 24 plots were sampled in areas previously designated as major infestation centers by the aerial detection survey. 2/ Fourteen of these plots were also sampled in 1958.

Timing the survey. The survey period extended from August 17 to September 11. Collections were timed so as to account for variations in insect development by latitude, exposure, and elevation. The timing of sampling in the egg stage is not as critical as in other stages of the budworm's life cycle, i.e., the pupal stage, but it must insure completion of oviposition and nearly complete hatching of eggs. Collections should be finished before the fall storms commence, since egg masses laid on new foliage adhere poorly, and can be easily dislodged by wind and rain.

Organization. The survey team consisted of a leader, chief examiner, four women foliage examiners, four collectors, and a technical advisor (fig. 1). Collections of sample branches were brought to a temporary field headquarters in Union, Oregon, where the branches were examined for egg masses. Final separation of egg masses and analysis were performed in Portland, Oregon.

The evaluation survey required 185 man-days: 51 in collecting; 120 examining; and 14 separating new and old egg masses and identifying associated insect material. Final separation required more time than usual due to (1) training an inexperienced man to perform this operation and (2) an abundance of associated insect material.

1/ Carolin, V. M. and W. H. Klein. Evaluation of spruce budworm egg populations, 1959. 3 pp. Oct. 23, 1959. (Unpublished report. Copy on file Pac. N.W. Forest and Range Expt. Station).

2/ Buckhorn, W. J. and P. W. Orr. Forest Insect Conditions in the Pacific Northwest during 1959. U. S. Forest Service, Pac. N.W. Forest and Range Expt. Station. 37 pp. (Processed) December 1959.

Sampling and collecting. Circular sample plots, each containing five dominant or codominant (codominant preferred) Douglas-firs or white firs, were established at least 5 chains from roads. Within an infestation the horizontal distance between plots varied from two to four miles, depending on the size of infestation. In rare instances where these minimum distances could not be adhered to, plots were separated from each other by an elevational difference of 1,000 feet, whenever possible. Roadside reference points and individual trees within each plot were clearly marked.

Since most trees were limb-free for the first 10 to 20 feet, access to the live crown was gained by using a 28-foot aluminum extension ladder. The collector climbed to midcrown, selected two branches from opposite quadrants and severed them with a pruning saw. To avoid dislodging egg masses, the sample branches were either thrown clear of the crown, butt end down, or carefully lowered with a rope. Subsamples were taken from each branch by removing the right side of one and the left side of the other. The remaining half branches were then measured as to foliated length and width.

If considerable travel was involved or the samples were subsequently to be stored 48 hours or longer, the individual half branches were cut up and placed in large plastic bags. Each bag was labeled as to branch, tree, and plot. On the other hand, if the branches were to be examined within 48 hours, they were placed directly in the vehicle and covered with a wet cloth. Although both methods proved satisfactory in reducing drying of foliage, each had some disadvantages. Placing the foliage in plastic bags tends to exert undue rubbing and pressure on the accumulated foliage which results in disfiguration and tearing of the soft egg masses. This increases the difficulty of separating new from old eggs. In transporting the half branch samples intact, the vibration of the vehicle along with the rubbing of foliage causes some needle drop. It is possible, though, to catch these needles on a large cloth placed on the bed of the vehicle; however, if one or more of these separated needles contained an egg mass, it would lose its identity, thus introducing error as well as hindering statistical analysis.

Examination. The examiners went over each branch and removed all budworm egg masses, both old and new, and all life stages of associated insects adhering to the foliage. The chief examiner sorted and placed the material in individual containers and labelled them corresponding to the appropriate plot, tree, and branch.

Most of the foliage was examined outdoors. However, during periods of inclement weather, examination took place under cover in an open-sided shed, where natural diffused light was the main source of illumination. Past experience has shown that under natural light minute objects are more readily seen and eye strain is reduced, thereby considerably reducing the chances of overlooking egg masses.

The final examination of insect material was performed with a stereoscopic binocular microscope. Spruce budworm egg masses were separated into two main categories: "old" - representing populations present in 1958 or earlier, and "new" - egg masses deposited in 1959, representing the 1960 feeding populations. Estimates were obtained on both parasitism and degree of non-hatching. The occurrence and relative abundance of associated species was recorded, including information on parasitism for such species as black-headed budworm.

Analysis. Research studies[3] on Douglas-fir have shown that there is no significant difference between density of one year's old egg masses and the previous year's new egg masses within the same plot; therefore, it has been recommended that the number of old egg masses found in a given year be used as an index of the previous year's population level. This relationship on Douglas-fir permits relatively accurate trend predictions from temporary plots sampled only during one year.

Since 20 of the 24 evaluation plots sampled in 1959 contained white fir, it was desirable to find out whether this old to new egg mass relationship on white fir also held true. Any comparison, therefore, would have to be based on those 14 plots sampled during two successive years, 1958-1959. A comparison of these 14 plots, 3 containing Douglas-fir and 11 containing white fir, is presented in table 2. Analysis was made on only those plots that exhibited moderate to high populations. Analysis of data from plots exhibiting low population densities would be inconclusive due to high sampling errors. Table 3 shows the statistical comparison between new and old egg mass counts on five plots, each containing moderate populations. From this it can be seen that on white fir there is a significant difference between the old and new counts during two successive years. On the Douglas-fir plot (Hat Point) there was no significant difference. Although this was the only Douglas-fir plot that was tested, it suggests that there is a relationship between the current old counts and the previous year's new counts as previously reported.

It bears emphasis that the findings for white fir are not taken as conclusive, but they provide a basis for future analysis in 1960 at which time more complete records will be taken. Until then, trend estimates will be made by comparing the density of the current year's new egg masses with the previous year's new egg masses on those plots sampled during 1958 and 1959. On those plots sampled only once (1959), trend predictions will be based solely on the difference between the current new and old egg mass counts. It is apparent from table 2 that, in almost all cases, the current old counts are significantly greater than the previous year's new counts. This relationship, then, would over-emphasize downward trend estimates and under-emphasize upward trend estimates.

3/ Carolin, V. M. and W. K. Coulter. Research Findings Relative to the Biological Evaluation of Spruce Budworm Infestations in Oregon. 39 pp. Dec. 14, 1959. (Unpublished report. Copy on file Pac. N.W. Forest and Range Expt. Sta.).

The density of new egg masses is used to indicate hazard posed by the new spruce budworm generation for the coming year. Standards which relate egg population levels to expected damage on Douglas-fir were developed by research during studies in central and northeastern Oregon. These standards are based on an average number of 42 eggs per mass with 80 to 90 percent of the eggs hatching; no difference in number of eggs per mass or percent hatching has been found between Douglas-fir and white fir in central and northeastern Oregon. However, correlations between egg populations and larval populations, then larval populations and percent defoliation, were established exclusively for Douglas-fir. It is known that a given larval population will produce greater visible damage on white fir than on Douglas-fir. Present research studies on comparative damage between Douglas-fir and white fir are incomplete; standards for white fir will eventually be constructed so that consistent interpretations of basic egg data can be made.

Since no studies of egg mass size and normal hatching had previously been made in southeastern Oregon (Fremont N.F.), these basic data were obtained during the 1959 survey. Conversion of these data was made in order to use existing standards based on 42 eggs per mass with 80 to 90 percent of the eggs hatching.

FINDINGS

Spruce budworm egg population levels and trends differed greatly within the region. In northeastern and central Oregon, egg populations were generally low and the trend downward. In southern Oregon, populations were generally medium to very high, and the trend upward. A review of trend estimates for 14 plots sampled both in 1958 and 1959 showed only one estimate to be in error (table 4). One small infestation was not detected in 1958; as a result, the flare-up of mixed spruce budworm and black-headed budworm populations on and adjacent to the Yakima Indian Reservation in 1959 was unanticipated.

Life stages of several associated insects were found on all plots. Although the stages were generally not suitable for measuring population levels and trends, the presence and relative abundance of these insects gives some indication of their status. Therefore, it is possible not only to detect, but to follow a build-up of some important insects that would otherwise go undetected. A good example is the potentially dangerous Douglas-fir tussock moth which has been found on five plots.

The results of the 1959 evaluation survey are discussed according to major infestation areas.

Southern Oregon

Fremont N. F. - In 1958, three outbreak centers of light intensity were observed near Lakeview for the first time since before 1940. The 1959 aerial survey reported an increase in both extent and intensity; top killing of white fir was reported near Rogger Peak and Kelly Creek. The results of the present evaluation survey are as follows:

A more intensive evaluation survey will be made in this area in 1960, and emphasis will be placed on determining the need for control in 1961.

New pupae as well as hatched eggs of the black-headed budworm, Acleris variana, were found on two plots; also one new cocoon of the Douglas-fir tussock moth was discovered on one plot.

Central Oregon

Malheur N. F. In 1958, following the aerial spraying project in which thousands of acres of epidemic infestation were treated, a few small centers of light damage remained. In 1959, these centers could not be detected, and only two new centers, both light in intensity, were mapped. Two evaluation plots established in 1958, both located near King Mountain, revealed the following:

Locality	Egg masses per 1000 sq.in.			1960	
	New in 1958	Old in 1959	New in 1959	Population level	Trend
	------ Number ------				
King Mnt. #1	0.7	1.9	0.2	Very low	Down
King Mnt. #2	0.4	2.1	0.2	Very low	Down

As predicted in 1958, the 1959 trend was downward, and will continue downward in 1960. Defoliation will be negligible. Several black-headed budworm pupae were found on both plots, and one cocoon of the tussock moth was recorded on one plot.

Ochoco N. F. The only budworm activity in 1958 was near Snow Mountain. This light infestation could not be detected during the 1959 aerial survey. In 1959, only two new infestation centers, both exhibiting negligible damage, were reported. The status of the budworm on two evaluation plots is as follows:

Locality	Egg masses per 1000 sq.in.			1960	
	New in 1958	Old in 1959	New in 1959	Population level	Trend
	------ Number ------				
Alder Springs	0.2	0.8	0.1	Very low	Uncertain
Snow Mnt.	0.1	1.2	0.0	Very low	Uncertain

The present level of budworm populations is extremely low and may possibly be even lower in 1960.

Black-headed budworm pupae were relatively numerous on both plots. Combined black-headed budworm and spruce budworm feeding will probably occur in 1960, but not enough to be significant.

Northeastern Oregon

Wallowa-Whitman N. F. No visible damage was reported on and adjacent to those areas sprayed in 1958. The Minam infestation which has been on the decline disappeared. Infestations in the Snake, Imnaha, and Pine Creek units that flared up in 1958, declined both in intensity and extent in 1959. In one area south of the forest boundary, Little Lookout Mountain, some mortality in the true fir stands occurred. The data obtained from nine plots showed the following trends:

Locality	Egg masses per 1000 sq.in.			1960	
	New in 1958	Old in 1959	New in 1959	Population level	Trend
	------ Number ------				
Sumpter Tipton	0.1	1.3	0.0	Very low	Uncertain
Duck Cr. #1	1.7	2.6	0.1	Very low	Down
Duck Cr. #2	0.3	0.2	0.1	Very low	Down
Fish Lake #1	1.4	2.0	1.4	Very low	Uncertain
Fish Lake #2	1.2	2.3	0.5	Very low	Down
Joseph-Lick Cr.	0.7	4.1	0.2	Very low	Down
Joseph-Harl Bu.	0.6	4.4	0.1	Very low	Down
Imnaha-Hat Pt. #1	4.2	5.4	1.1	Very low	Down
Imnaha-Hat Pt. #2	-	11.5	4.1	Low	Down

A comparison of old and new egg masses on all plots shows a significant downward trend. In the Hat Point area, though the trend is downward, the forthcoming population may still be high enough to cause slight but noticeable defoliation. On the remaining areas, feeding will be at a minimum.

Five tussock moth cocoons were found on three plots: two each on the Fish Lake plots, and one on the Harl Butte plot. The pine needle scale was abundant on the Tipton plot.

Washington

Yakima I. R. and adjacent lands. A new infestation center covering nearly 10,000 acres was reported for the first time since 1957 on both sides of Simcoe Ridge, about 20 miles north of Goldendale, Wash. The findings from two plots brought out the following:

Locality	Egg masses per 1000 sq.in.		1960	
	Old in 1959	New in 1959	Population level	Trend
	------ Number ------			
Simcoe Ridge #1	0.6	0.6	Very low	Uncertain
Simcoe Ridge #2	0.2	1.5	Very low	Up

Ground examination coupled with survey findings showed that damage was caused by mixed feeding of the spruce budworm and black-headed budworm. The status of the latter insect is not known, but indications point to an upward trend in spruce budworm populations. Damage is expected to be light but noticeable in 1960.

DISCUSSION

During the 1958 evaluation survey, many problems were encountered that required immediate solutions. These solutions led to changes in methods and refinement of techniques. They were then adapted for use during the 1959 survey to make the most efficient use of time, available manpower and facilities. Although the evaluation survey is now operational, problems still arise that require modification of existing methods. The primary problems are: (1) Frequent changing of plot locations (2) long distances involved in collecting, and (3) timing of the collections with that of the examination. The latter problem is related to the first two. Normally, ten to fifteen half-branches can be examined per day, depending on the experience of the examiners, size of foliage samples, and abundance of insect material on the branches. For example, an average of 15 branches (1-1/2 plots) were examined in 1958, whereas in 1959, only 10 branches (1 plot) per day were completed. On the other hand, the field crew can usually collect foliage samples from one to three plots per day, depending on the travel distance, which in the past has varied from 150 miles round-trip (Tipton) to 700 miles round-trip (Lakeview). When long distances are involved, it has been past practice to employ a three-man crew, with two men collecting and one man delivering. Otherwise both operations are performed by the same crew.

Coordination of collections with examination became less important with the use of large (20" x 30") plastic bags. Before their use, these activities had to be timed so that collecting did not exceed examining by more than two plots at any one time. These airtight plastic bags retard foliage dessication, thereby prolonging the permissive period between collection and examination.

PLANS FOR 1960

Recommendations for increasing survey efficiency and for improving techniques on the 1960 evaluation survey are as follows:

1. Care will be taken in placing foliage into plastic bags. Instead of crowding the entire half branch in one bag (the usual practice), two or more bags will be used. The foliage will then be evenly distributed between the bags.

2. The place at which sample branches are examined will be centrally located. It is probable that a new team of examiners and a new examination site will be required for the efficient processing of foliage from the Fremont N. F. plots in 1960. Because of the upward trends at these plots, it is likely that this area will be sampled intensively; the probability of adding new plots, as well as resampling the old ones, is strong. If this situation materializes, the sample foliage will be examined locally, preferably at the Warner District Ranger Station. By hiring local personnel and locating the examination point contiguous to the sampling areas, the need for a third collector will be eliminated and travel between collection and examination will be minimized.

3. Upon completion of the aerial survey, the survey leader and the chief examiner will work out a flexible itinerary for the collecting crew, taking into consideration the mechanical and biological variables. Once this is accomplished, the survey leader will establish and prepare explicit directions for sampling each new plot.

4. The usefulness of the plots will be evaluated each year. Of the 24 plots sampled in 1959, several will be resampled in 1960, some will be added and others will be dropped. Resampling of the existing plots will be determined by either present population level, trend, or presence and relative abundance of potentially dangerous associated insects, as determined by the 1959 evaluation survey. Location and sampling of new plots will depend on the outcome of the 1960 aerial survey. The tentative status of the present plots is shown in table 5.

5. Trend estimates will be obtained from plots containing subalpine fir in the Imnaha-Hat Point area in 1960. Past trend estimates from this area have been from Douglas-fir. Sampling of subalpine fir has been avoided because information relating population levels to expected damage is lacking. Nevertheless, population trend can still be predicted, and since subalpine fir is a dominant species at higher elevations, the resulting trend estimates will more accurately portray the actual trend conditions of the budworm in these stands.

6. Estimates of defoliation will be obtained for trees on the trend plots during 1960. Defoliation estimates will be simplified by setting up specific standards beforehand. In order to eliminate variation between observers, all estimating will be done by the same team.

A P P E N D I X

FIGURE 1--ORGANIZATION CHART-1959 SPRUCE BUDWORM EGG POPULATION SURVEY

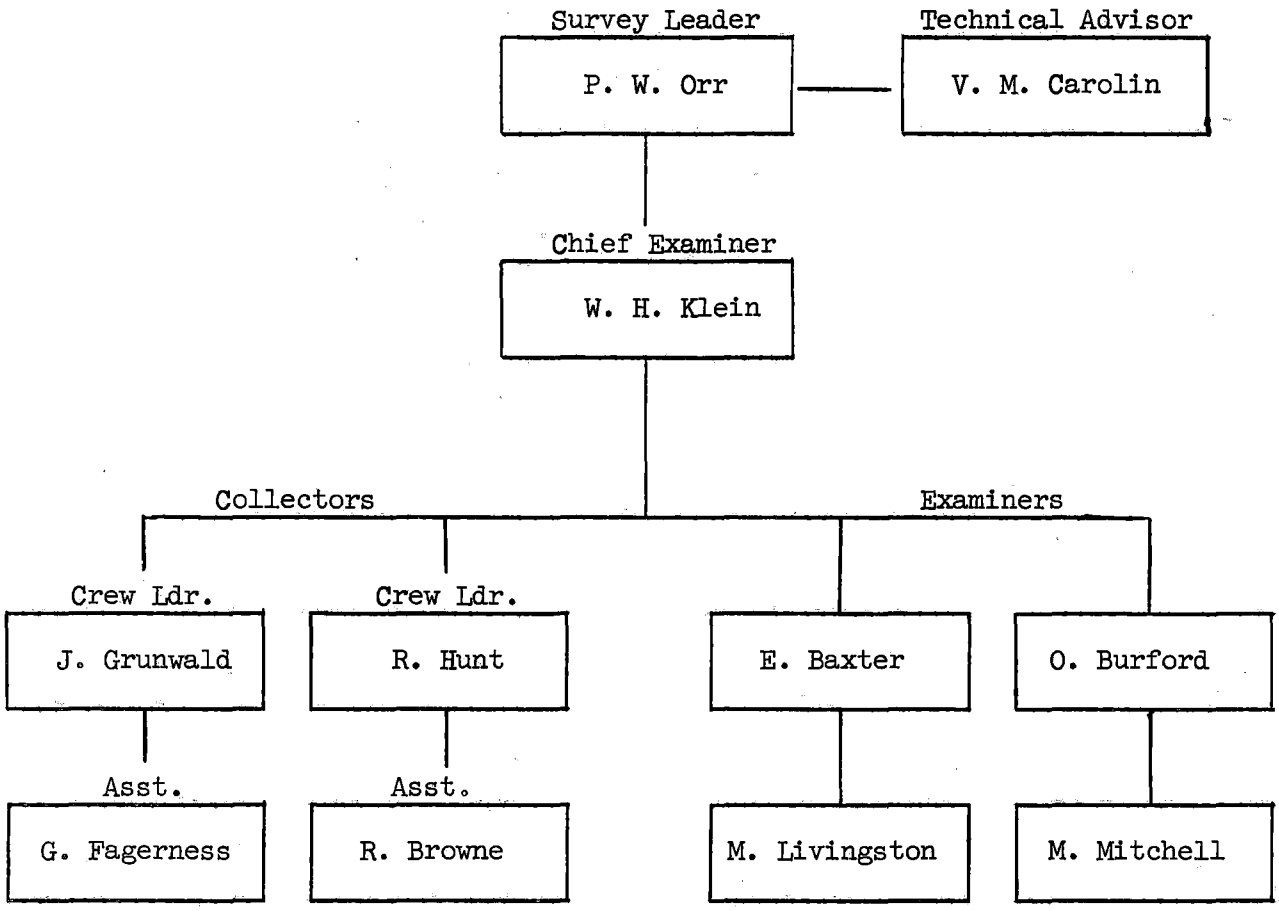

Table 1.--Extent of spruce budworm infestations in Oregon and Washington in 1959, by control unit and intensity of infestation
(In acres)

Administrative area 1/ and control unit	Intensity of infestation			All intensities
	Light	Moderate	Heavy	
Wallowa-Whitman N. F.:				
Snake	29,920	27,680	8,160	65,760
Joseph	26,560	1,280	0	27,840
Pine Creek	15,680	4,160	0	19,840
Total	72,160	33,120	8,160	113,440
Fremont N. F.:				
Dairy Creek	28,480	20,480	0	48,960
Warner Mountains	24,160	4,000	5,280	33,440
Total	52,640	24,480	5,280	82,400
Malheur N. F.:				
Aldrich Mountain	1,440	0	0	1,440
Lookout Mountain(B.L.M.):				
Lookout Mountain	1,240	440	360	2,040
Yakima I. R.:				
Simcoe Butte	4,800	0	0	4,800
Glenwood District(WSDNR):				
Simcoe Butte	5,160	0	0	5,160
All units	137,440	58,040	13,800	209,280

1/ N. F., National Forest; B. L. M., Bureau of Land Management; I. R., Indian Reservation; W. S. D. N. R., Washington State Department of Natural Resources.

Table 2.--Comparison of 1958 new with 1959 old egg mass counts on 14 evaluation plots in southern, central, and northeastern Oregon, 1958-1959

Forest	Locality	Tree species	Egg masses per 1000 sq.in.	
			New in 1958	Old in 1959
			----- Number -----	
Fremont N. F.	Picture Flat	White fir	0.7	2.9
	Coleman Ridge	White fir	4.4	8.2
Malheur N. F.	King Mnt. #1	White fir	0.7	1.9
	King Mnt. #2	White fir	0.4	2.1
Ochoco N. F.	Alder Spr.	White fir	0.2	0.8
	Snow Mnt.	White fir	0.1	1.2
Wallowa-Whitman N. F.	Sumpter-Tipton	Douglas-fir	0.1	1.3
	Duck Cr. #1	White fir	1.7	2.6
	Duck Cr. #2	White fir	0.3	0.2
	Fish Lake #1	Douglas-fir	1.4	2.0
	Fish Lake #2	White fir	1.2	2.3
	Joseph-Lick Cr.	White fir	0.7	4.1
	Joseph-Harl Bu.	White fir	0.6	4.4
	Imnaha Hat Pt.	Douglas-fir	4.2	5.4

Table 3.--Statistical comparison of new and old egg masses on five evaluation plots in southern and northeastern Oregon, 1958-1959

Forest	Locality	Tree species	Egg masses per 1000 sq.in.: New in 1958	Old in 1959	$S_{\bar{d}}$	"t"
			---- Number ----			
Fremont N. F.	Coleman Ridge	White fir	4.4	8.2	1.71	2.68*
	Picture Flat	White fir	0.7	2.9	0.67	3.35*
Wallowa-Whitman N. F.	Joseph-Harl Bu.	White fir	0.6	4.4	0.58	5.91**
	Joseph-Lick Cr.	White fir	0.7	4.1	0.96	4.01*
	Immaha-Hat Point	Douglas-fir	4.2	5.4	1.94	0.36 1/

* Significant at .05 level
** Significant at .01 level
1/ Non-significant

Table 4.--Comparison of 1958 trend predictions with actual trend as determined by the 1959 spruce budworm egg population survey

Administrative area and sampling locality	1958 Egg masses per 1000 sq.in. of foliage		1958 Trend prediction	1959 Egg masses per 1000 sq.in. of foliage	Trend 1958 new vs. 1959 new
	OLD	NEW		NEW	
	---Number--			---Number---	
Fremont N.F.					
Picture Flat	2.2	0.7	Down	6.7	Up
Coleman Ridge	4.1	4.4	Up	10.7	Up
Malheur N.F.					
King Mnt. #1	3.7	0.7	Down	0.2	Down
King Mnt. #2	0.6	0.4	Down	0.2	Down
Ochoco N.F.					
Alder Springs	0.9	0.2	Down	0.1	Down
Snow Mountain	1.2	0.1	Down	0.0	Down
Wallowa-Whitman N.F.					
Sumpter-Tipton	2.3	0.1	Down	0.0	Down
Duck Cr. #1	6.3	1.7	Down	0.1	Down
Duck Cr. #2	1.6	0.3	Down	0.1	Down
Fish Lake #1	2.2	1.4	Down	1.4	Uncertain
Fish Lake #2	1.3	1.2	Uncertain	0.5	Down
Joseph-Lick Cr.	6.1	0.7	Down	0.2	Down
Joseph-Harl Bu.	6.9	0.6	Down	0.1	Down
Hat Point	4.6	4.2	Uncertain	1.1	Down

Table 5.--Plan for sampling existing budworm evaluation plots in 1960

To be sampled in 1960		To be dropped in 1960	
Area	Locality	Area	Locality
Fremont N. F.	Picture Flat	Deschutes N. F.	Fly Creek
	Coleman Ridge		
	Summit Prairie		
	Rogger Peak	Malheur N. F.	King Mnt. #1
	Pothole Creek		King Mnt. #2
	Kelly Creek		
	Drake Spring		
	Mitten Spring	Ochoco N. F.	Snow Mnt.
Ochoco N. F.	Alder Springs	Wallowa-Whitman N. F.	Sumpter-Tipton
			Duck Cr. #1
			Duck Cr. #2
Wallowa-Whitman N. F.	Fish Lake #1		Joseph-Harl Butte
	Fish Lake #2		Joseph-Lick Creek
	Imnaha-Hat Pt. #1		
	Imnaha-Hat Pt. #2		
Yakima Indian Res.	Simcoe Ridge #1		
	Simcoe Ridge #2		